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Date: 16 MAY 1972

AN INVESTIGATION OF THE
CHARACTERISTICS OF FLECHETTE ROUNDS WHEN
FIRED FROM A MULTI-BARRELED TEST GUN (U)

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BALLISTIC RESEARCH LABORATORIES

TECHNICAL NOTE NO. 1379

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AN INVESTIGATION OF THE CHARACTERISTICS OF FLECHETTE
ROUNDS WHEN FIRED FROM A MULTI-BARRELED TEST GUN (U)

S. S. Lentz

Department of the Army Project No. 502-08-006
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Aberdeen Proving Ground, Md.
February 1961

AN INVESTIGATION OF THE CHARACTERISTICS OF FLECHETTE
ROUNDS WHEN FIRED FROM A MULTI-BARRELED TEST GUN (U)

ABSTRACT

Experimental firings were conducted with a five-barreled test gun firing Cal. 0.22, single flechette rounds in single shots, in salvos, and in a burst at a rate of fire of 2680 rds/min. Measurements were made of action time and velocity; dispersions were obtained of the flechettes and sabots at several locations down range and photographs were taken of the flechettes and sabots at two positions along their trajectories. Observations from the targets and photographs indicate that most flechettes yaw in flight regardless of how they are fired. Those fired in salvos, or in a burst, yaw much more than those fired in single shots. Yaw may be induced by transverse forces set up by the motion of the gun tubes, blast from adjacent muzzles, shock waves from other flechettes and interference from the sabots.

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A Cal. 0.22, five-barreled test gun, and fifty single flechette rounds were received from Aircraft Armaments, Inc., for a general investigation of the gun and ammunition. In addition, a verbal request was received from the Ordnance Weapons Command which permitted the Ballistic Research Laboratories to use their own discretion in the investigation.

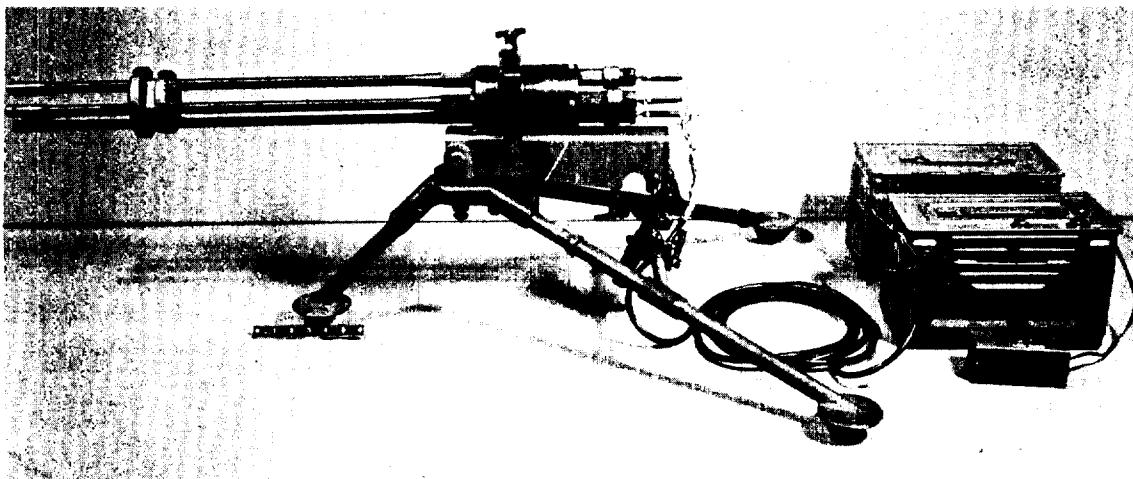


FIGURE 1

CAL. 0.22 FIVE-BARRELED GUN MOUNTED ON AN M2 TRIPOD
WITH THE ELECTRICAL FIRING COMPONENTS

The Cal. 0.22 five-barreled test gun, mounted on an M2 tripod, is shown in Figure 1. The center lines of the five barrels are spaced at equal increments of 72 degrees around the circumference of a circle having a diameter of 2.3 inches. The breech ends of the tubes are threaded into a breech ring containing five chambers and the muzzle portions of the tubes are clamped rigidly to a cylindrical bracket located several inches to the rear of the muzzles. Attached to each muzzle is a stripper for separating the sabot from the flechette. The breech block contains five individual firing pin mechanisms with caps threaded on the rear of each mechanism for loading electric primers. In addition, the breech block is hinged so that it may be operated from either side of the weapon by pulling the hinge pin on the side from which it is to be opened.

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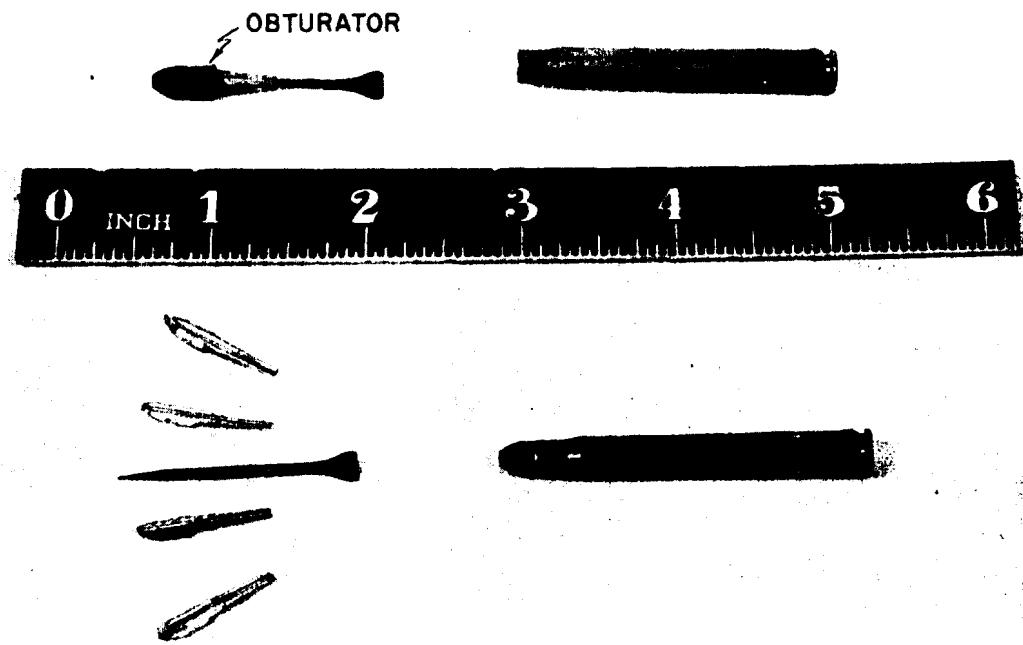


FIGURE 2
CAL. 0.22, SINGLE FLECHETTE ROUND

The Cal. 0.22, single-flechette round is shown in Figure 2. The round consists of the cartridge case with a piston actuated percussion primer, the propellant, a single flechette and a sabot which encloses the forward portion of the flechette. The magnesium alloy sabot is assembled in quarters and held together by a coating of teflon. A small plastic ring near the mid-point of the sabot is used for obturation. Two rounds were disassembled, photographed, and weighed. The weights of the components were as follows:

Complete round	-	93.366 grains
Propellant	-	13.040 grains
Flechette	-	9.568 grains
Sabot	-	6.790 grains

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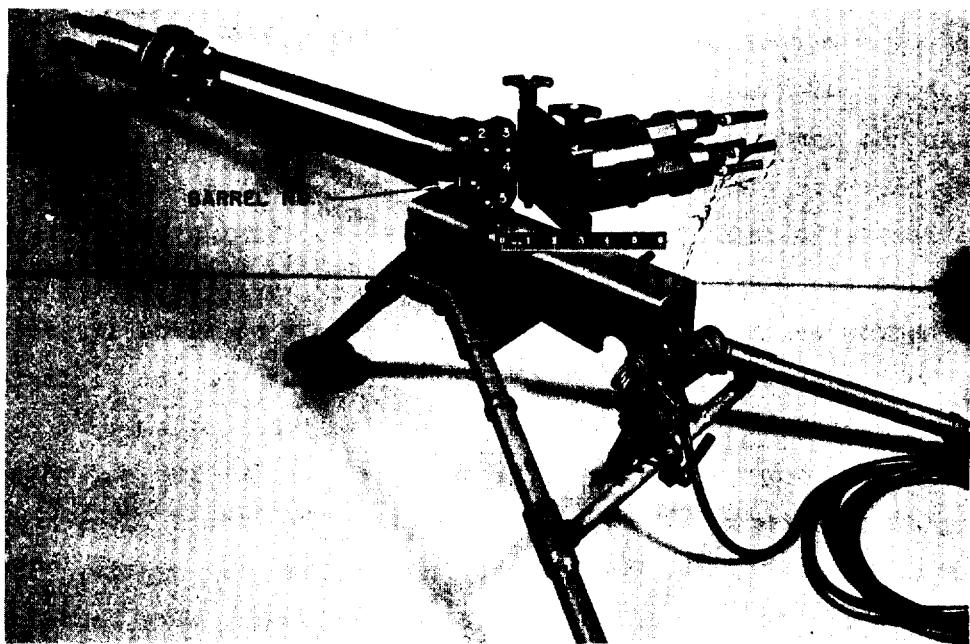


FIGURE 3

CAL. 0.22 TEST GUN MOUNTED ON AN M2 TRIPOD WITH THE BREECH ASSEMBLY OPEN

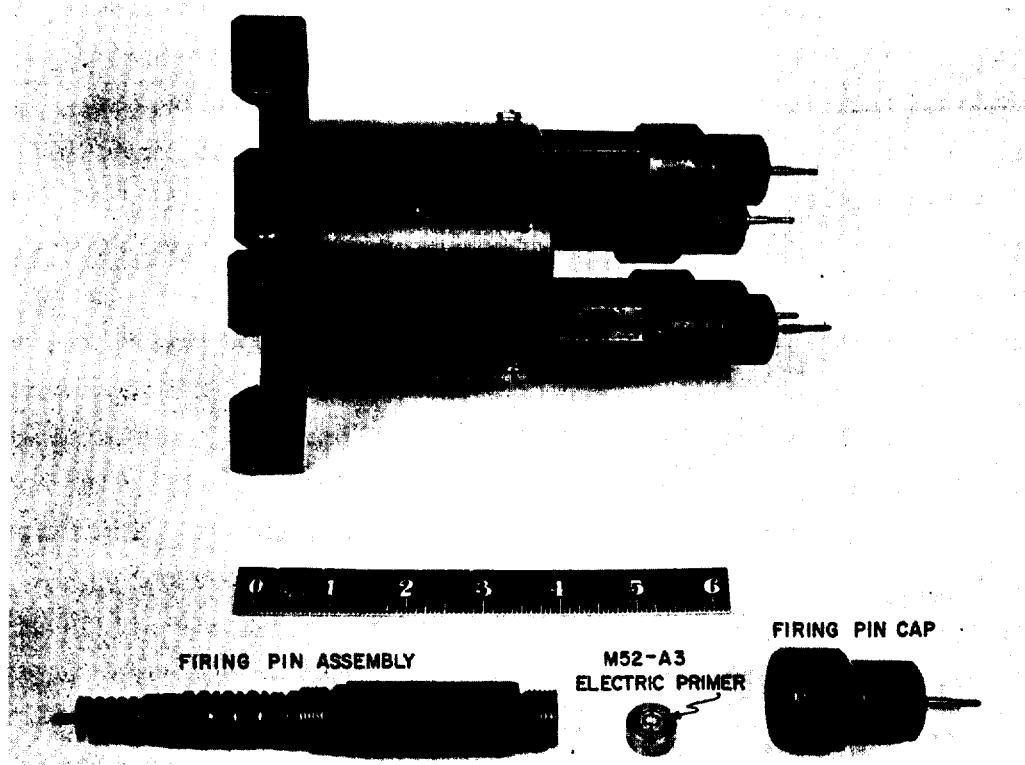


FIGURE 4

BREECH BLOCK SHOWING THE FIRING PIN,
M52-A3 ELECTRIC PRIMER AND THE FIRING PIN CAP

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In firing, the rounds are loaded directly into the five chambers shown in Figure 3. After closing the breech block, five M52-A3 Electric Primers are loaded into the threaded caps at the rear of the assembly as shown in Figure 4. The electric primers are ignited by the discharge from a condenser and the pressure following the ignition drives the firing pin forward to strike and fire the percussion primer assembled in the base of the cartridge case. The rounds in each of the five barrels may be fired in sequence with a rotary switch at the rate of 2680 shots per minute or the firing circuit may be re-wired to fire all five rounds simultaneously.

The firings were conducted in an indoor range with the gun and tripod sitting on a platform approximately 15 inches above the floor. Sandbags were placed on all three legs of the tripod to stabilize the system. Three screens consisting of thin paper, stapled to wooden frames, were placed at intervals of approximately 5, 10, and 15 feet from the muzzle to record the patterns of the flechettes and sabots. In addition, a target was placed 42 feet beyond the muzzle to obtain the dispersion of the flechettes at that point.

The times from the initiation of the electric primer to the muzzle contact (action time), from the muzzle contact to the first screen, and from the muzzle contact to the target were recorded with three Berkley Chronographs. These times were used to determine the variation in action time and to calculate the velocity of the flechettes.

Photographs were taken of the flechettes and sabots in flight with a plate camera and two microflash units set up perpendicular to the line of fire, several feet forward of the muzzle. The shutter on the camera was held open in the darkened range during firing and the two flashes from the microflash units framed the flechettes and sabots on each plate at two positions along their trajectories. The microflash units were sequenced by pulse and wave form generators which were initiated by the muzzle contact. The first microflash was triggered just after the flechettes and sabots cleared the flash from the propellant gases at the muzzle and the second microflash was triggered approximately 500 microseconds after the flash of the first unit.

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TABLE I

Record No.	Method of Firing	Action Time ms	V ft/sec	Photo	R ₁	R ₂	R ₃	Target Dispersion in. at 42'		Purpose
					in. at 5'	in. at 10'	in. at 15'	x	y	
1	Single Round	100.072	--	--	3.5	17.4	29.1	--	--	Rounds fired single shot from barrel No. 1 to photograph the attitudes of the flechettes in flight and also to determine the cone angle formed by the separation of the four quarters of the sabot.
2	Single Round	100.348	--	--	3.9	17.6	31.5	--	--	
3	Single Round	97.044	4385	--	--	--	--	--	--	
4	Single Round	96.305	4278	--	--	--	--	--	--	
5	Single Round	97.788	--	X	--	--	--	--	--	
6	Single Round	97.721	--	X	3.0	12.5	20.0	--	--	
7	Single Round	97.799	--	--	3.8	14.5	19.0	--	--	
8	5 rd. Salvo	--	--	--	--	Screen No. 1 removed.	8.00	9.56	Rounds fired simultaneously from all five barrels to photograph the attitudes of the flechettes in flight, to obtain the target dispersion and to see if there could possibly be any interference from the sabots.	
9	5 rd. Salvo	--	4534	X	--		2.81	6.06		
10	5 rd. Salvo	--	4605	X	--		4.13	6.91		
11	5 rd. Salvo	--	4558	X	--		5.19	2.37		
12	4 rd. Salvo	--	4494	X	--		2.11	6.44		
13	5 rd. Salvo	--	4587	X	--		3.03	4.69		
14	5 rd. Burst (Rate=2680 rds/min)	--	4486	X	--		3.94	6.00	To compare the target dispersion with the groups of 5 rds. fired simultaneously. Velocity measurement and photograph taken of 3rd round in burst.	
15	5 single rds; 1 rd./barrel	--	--	X	3.1	16.1	22.3	5.92	3.32	To compare the target dispersion with the groups of 5 rds. fired simultaneously and the 5 rds. fired in a burst.

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The microflash units were delayed to prevent concealment of the flechettes and sabots by smoke and to prevent fogging of the film by flash. In firing single rounds, the flash extended approximately 20 inches forward of the muzzle and in salvos of four or five rounds the flash extended up to 50 inches forward of the muzzle.

The data obtained from firing the flechette rounds are tabulated in Table I. These data include the firing of single rounds, four and five round salvos and one five-round burst at the rate of 2680 rounds per minute. The purposes for firing the test gun in this manner are given in the right hand column of the table.

From the table, it can be observed that the action times of the seven single rounds varied 4.043 ms. This can be attributed primarily to the friction encountered by the numerous components in the firing pin mechanism. Originally, the microflash timing sequence was intended to be initiated by the discharge of the condenser through the electric primer; however, since the action time was so erratic, the microflash units were initiated by a muzzle contact.

Velocity measurements obtained for all single rounds were recorded over a baseline of 5.02 feet, extending from the muzzle contact to the first screen. Velocity measurements obtained for four and five round salvos were recorded over a baseline of 10.27 feet, extending from the muzzle contact to the second screen. The first screen was removed so that the field of view of the camera could be relocated further down range because of the increased length of the flash at the muzzle. The average velocity obtained for the leading flechette in each salvo was 4544 fps.

Photographs were taken of the single flechettes at distances of approximately 25 and 42 inches from the muzzle. Flechettes fired in salvos or in a burst were photographed at distances of approximately 53 and 75 inches from the muzzle. Photographs showing the two exposures of the same flechettes and sabots along their trajectories are shown in Figures 5, 6, 7 and 8. From these photographs, one can observe that the flechettes contain considerable yaw when fired simultaneously because of the transverse forces

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≈ 75" FROM MUZZLE

≈ 53" FROM MUZZLE

FIGURE 5

PHOTOGRAPH OF A FIVE-ROUND SALVO (RECORD NO. 10)

NOTE: ONLY THREE FLECHETTES CAN BE SEEN
BECAUSE OF THE VARIATION IN ACTION TIME.



≈ 75" FROM MUZZLE

≈ 53" FROM MUZZLE

FIGURE 6

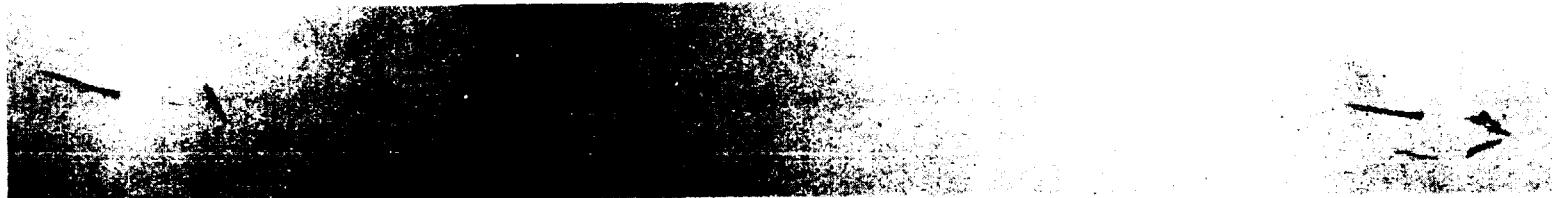
PHOTOGRAPH OF A FOUR-ROUND SALVO (RECORD NO. 12)

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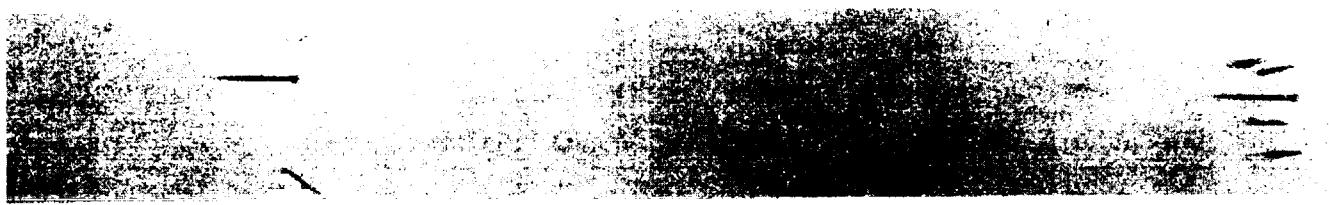


≈ 75" FROM MUZZLE

≈ 53" FROM MUZZLE

FIGURE 7

PHOTOGRAPH OF THE THIRD FLECHETTE IN A BURST OF FIVE ROUNDS
FIRED AT A RATE OF 2680 RDS./MIN. (RECORD NO. 14)



≈ 42" FROM MUZZLE

≈ 25" FROM MUZZLE

FIGURE 8

PHOTOGRAPH OF A SINGLE FLECHETTE AND SABOT
WHEN FIRED SINGLE SHOT (RECORD NO. 15)

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acting on the flechette. Forces tending to produce yaw emanate from the motion of the muzzle, from the blast of adjacent muzzles, from the shock waves produced by other flechettes and from interference with the sabots. The inherent variation in action time make it impossible for the flechettes to emerge from the muzzle simultaneously, and eliminate most of the effects tending to produce yaw.

The separation of the sabot from the flechette is not always uniform. One or more sections appear to retain contact with the flechette for some time after the first sections of the sabot start to break away. Unequal separation of the four parts of the sabot will induce yaw in the flechette. An example of unequal separation of the sections of the sabot may be observed in Figure 7 and an example of uniform separation may be observed in Figure 8.

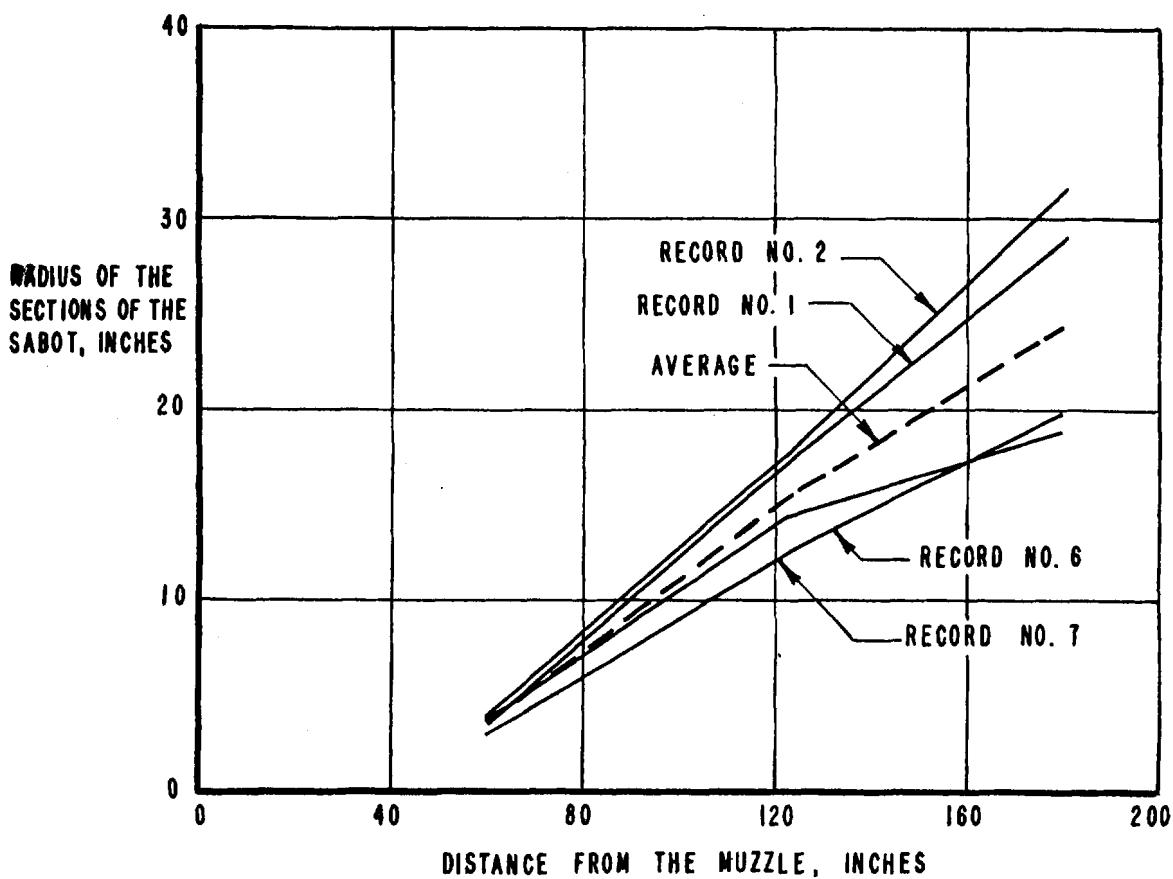


FIGURE 9-RADIUS OF THE SECTIONS OF THE SABOT VS. DISTANCE FROM THE MUZZLE.

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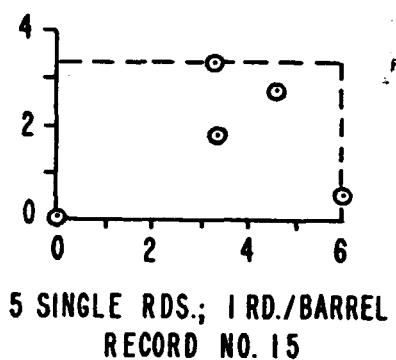
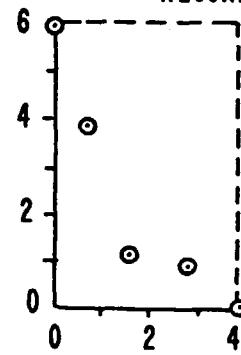
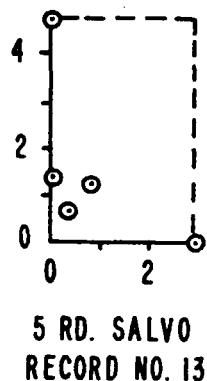
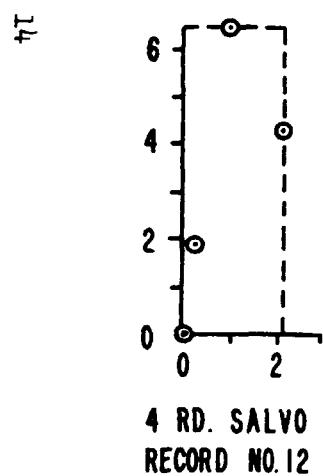
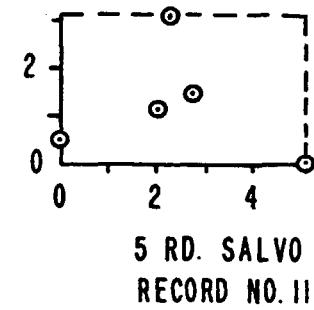
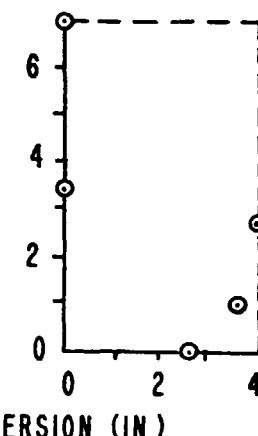
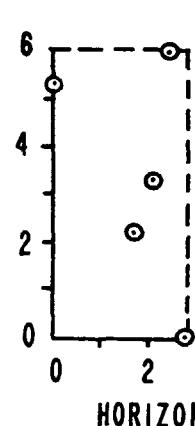
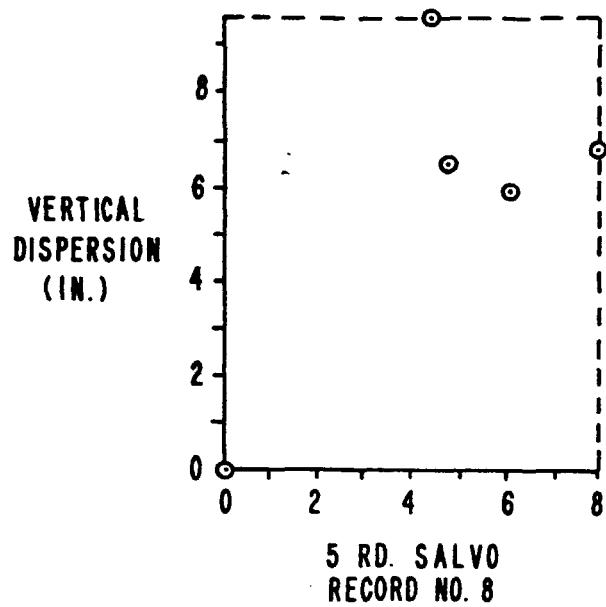


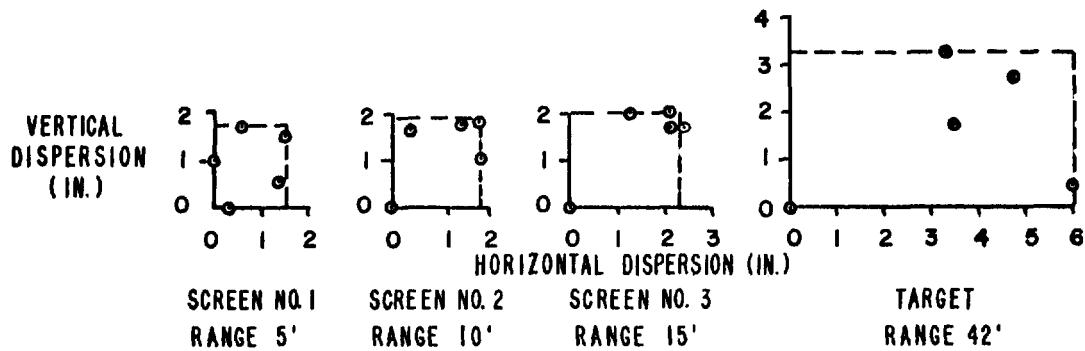
FIGURE 10
TARGET PATTERNS OF THE FLECHETTES
OBTAINED AT A RANGE OF 42 FEET

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Measurements were made of the average radius of the four sections of the sabot relative to the impact point of the flechette on three screens. A graph of these radii plotted as a function of distance from the muzzle is shown in Figure 9. As shown in the graph, the sections of the sabot remain close to the flechette over the first 42 inches of travel from the muzzle and then separate at a cone angle of approximately 20 degrees.

Targets were obtained at a range of 42 feet. The patterns and maximum dispersion in the vertical and the horizontal directions are given in Figure 10. From this small sample there appears to be no correlation as to pattern or to dispersion of those rounds fired in salvos and no significant difference in the target dispersion whether the rounds from each barrel be fired single shot, simultaneously, or in a burst.

In Record No. 15, which is tabulated in Table I, five rounds were loaded into the test fixture and fired single shot without molesting the weapon. Target patterns were taken of the five flechettes at each of the three screens and also at the target. Figure 11 shows the relative positions



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of the flechettes at these four points. At the first screen, the flechettes are grouped closer together than they were at emergence from the muzzles, indicating that the barrels bow in toward the centerline of the five muzzles. After passing through the thin aluminum foil velocity screen at Screen No. 1, the pattern of the flechettes changed rapidly. Thus, it appears that the two sheets of thin aluminum foil placed approximately five feet forward of the muzzle tend to alter the paths of the flechettes considerably.

From this investigation, the following observations can be made:

- a. Flechettes fired in salvos yaw greatly because of the transverse forces induced by the motion of the muzzle during the launching, blast from adjacent muzzles, shock waves produced by other flechettes and interference of the sabots either from adjacent rounds or in separation.
- b. Practically all flechettes yaw in flight as observed from the configuration of the impacts on the three screens and the target.
- c. The flight characteristics of the flechettes appear to be altered by thin foil or paper screens.
- d. The target patterns and dispersion obtained from this small sample indicates no significant difference when one round is fired from each of the five barrels in single shots, simultaneously or in a burst at a cyclic rate of 2680 rds./min.

ACKNOWLEDGEMENTS

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